UDC 621.391.812.62.
621.3.029.63

BBC

RESEARCH DEPARTMENT

1969
THE QUEEN'S AWARD
TO INDUSTRY

REPORT

Long distance tropospheric propagation measurements at u.h.f. over mixed land and sea paths crossing the English Channel

No. 1971/31

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

Research Department Report No. 1971/31

LONG DISTANCE TROPOSPHERIC PROPAGATION MEASUREMENTS AT U.H.F. OVER MIXED LAND AND SEA PATHS CROSSING THE ENGLISH CHANNEL

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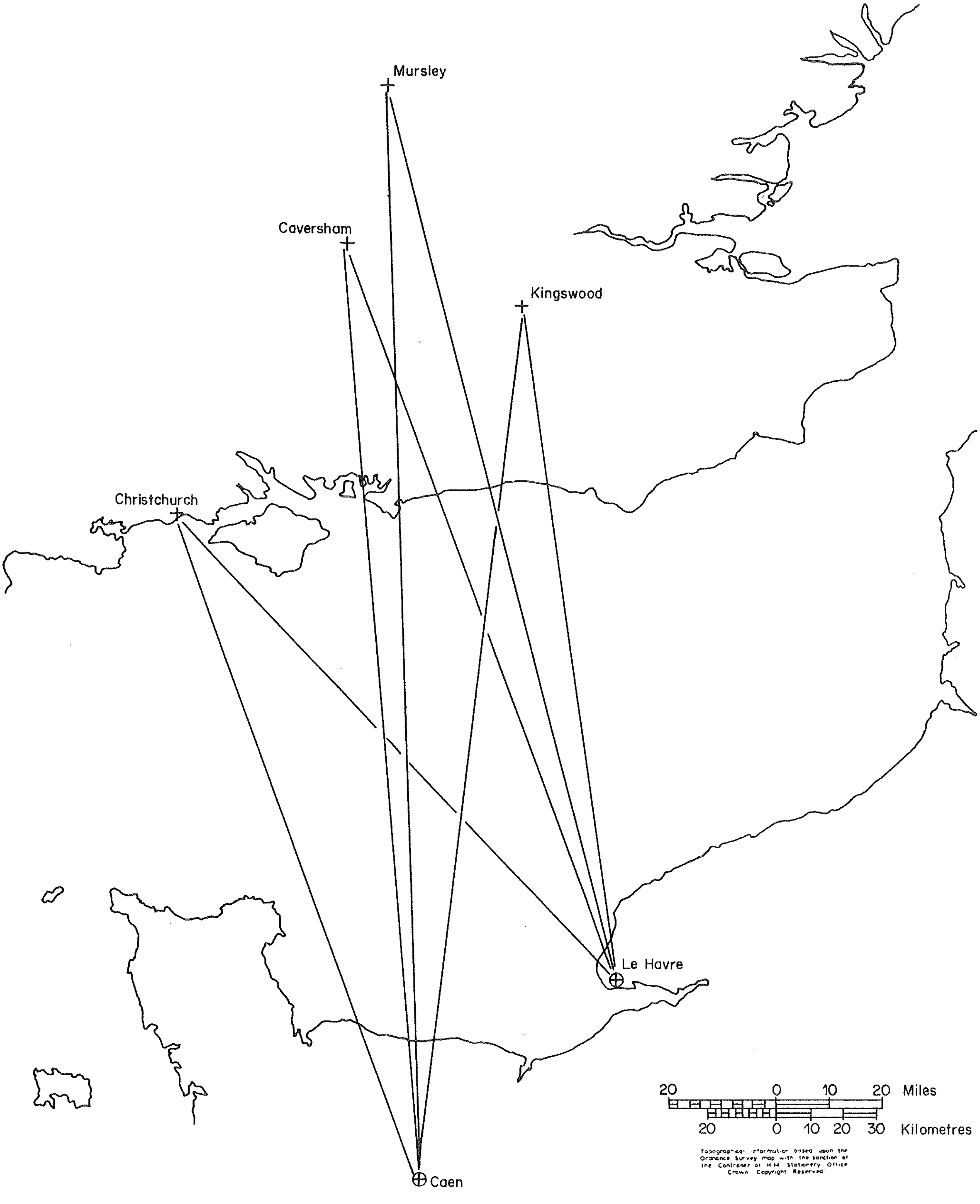

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Fig. 1 - Location of transmitting and receiving sites

⊕ Transmitting site + Receiving site

September 1971

Research Department Report No. **1971/31**
UDC 621.391.812.62
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LONG DISTANCE TROPOSPHERIC PROPAGATION MEASUREMENTS AT U.H.F. OVER MIXED LAND AND SEA PATHS CROSSING THE ENGLISH CHANNEL

Summary

This report gives the results of a series of long-term tropospheric propagation measurements carried out at u.h.f. over a number of mixed land and sea paths of lengths ranging from 195 km to 330 km. These measurements, which supplement the data available for frequency planning, are compared with values estimated by two prediction methods. This comparison, in association with a corresponding analysis of previously available results over such paths indicates that one of these methods tends to significantly overestimate field strengths. An amendment to this method is suggested which would reduce the mean error of prediction, but it would seem that significant improvements in prediction accuracy can only be achieved by taking account of the full transmission-path profile.

1. Introduction

The results of a substantial number of long-distance propagation measurements in Bands IV and V have been submitted to the International Radio Consultative Committee (CCIR) and used to derive the separate overland and oversea curves given in CCIR Recommendation 370-1.[1] These curves are used by broadcasting authorities to assess interference problems resulting from channel sharing.

In view of the essential differences between the curves relating to overland and oversea paths there also is an obvious need for a method to enable estimates of field strength to be made for mixed land/sea paths. To supplement the very limited data at that time available relating to such paths, the BBC (in conjunction with the Netherlands Postal and Telecommunications Service) carried out in 1963/4 a series of mixed land/sea path measurements at 560 MHz.[2,3] Resulting from these measurements a method of predicting field strengths over mixed paths was proposed by interpolation between the oversea and overland curves. This method was submitted to the CCIR and is that currently recommended for mixed land/sea path calculations.[4]

To investigate further the validity of the method a second series of mixed-path measurements was carried out, this time at 774 MHz.[5] As before, the transmitter was at Scheveningen (Holland) but a different series of receiving sites was employed, thereby providing a new series of transmission paths. From this second series of measurements it was concluded that field-strength predictions estimated by the current CCIR mixed-path method were in good agreement with the measured values provided that the proportion of land path was low. For greater proportions of land the agreement was poor, the measured values being substantially lower than predicted.

In view of this major discrepancy between the results of these two series of measurements it was apparent that further work was urgently needed to attempt to resolve the anomaly. Accordingly a measurement campaign was initiated in conjunction with the ORTF, using the u.h.f. stations at Caen and Le Havre as transmission sources. The television sound-channel transmissions from both stations were recorded at a site on the south coast of England (Christchurch) and at three other sites at differing distances from the coast. These transmission paths are shown in Fig. 1.

2. Transmitting and receiving sites

2.1 Transmitting sites

Details of transmitting sites and radiating characteristics are given in Table 1. It may be noted that the Caen station operates in Band IV, is sited some 45 km inland from the French coast and has an effective

TABLE 1

Transmitting site details

Transmitter	Sound Channel Frequency (kHz)	Site Height a.m.s.l. (m)	Aerial Height a.g.l. (m)	Estimated Ae. Ht. above mean terrain (m)	Latitude	Longitude	Modulation System (sound)	Sound Channel e.r.p. dB rel. to 1 kW
Caen	509·75	345	200	400	48°58′N	00°37′W	A.M.	18 to 20*
Le Havre	653·75	84	105	175	49°30′N	00°11′E	A.M.	3 to 8*

* Range of e.r.p. over arc subtending receiving sites

transmitting aerial height of approximately 400 m above mean terrain. The Le Havre station operates in Band V, is less than 10 km inland on the bearing towards the receiving sites, and has an effective aerial height of 175 m. Thus these two sources provide a greater variability in transmission parameters than were available from previous measurements made by the BBC over sea paths and mixed land/sea paths all of which had used the same transmitting site at Scheveningen.

2.2 Receiving sites

The four receiving stations used for this experiment are also shown in Fig. 1. The inland sites were at Kingswood (Surrey), Caversham (Oxfordshire) and Mursley (Buckinghamshire). Path profiles extending along the respective transmission paths from these receiving sites to the English Channel are shown in Fig. 2. The fourth receiving site at Christchurch (Hampshire) was on the south coast of England and may be considered as the reference site, albeit it should be noted that the paths terminating here were not entirely oversea since the transmitting sites were both effectively inland.

Receiving aerials were 10-element Yagi arrays mounted approximately 10 m above ground level with the exception of those at Christchurch, and of the aerial used for reception of the Le Havre transmission at Kingswood.

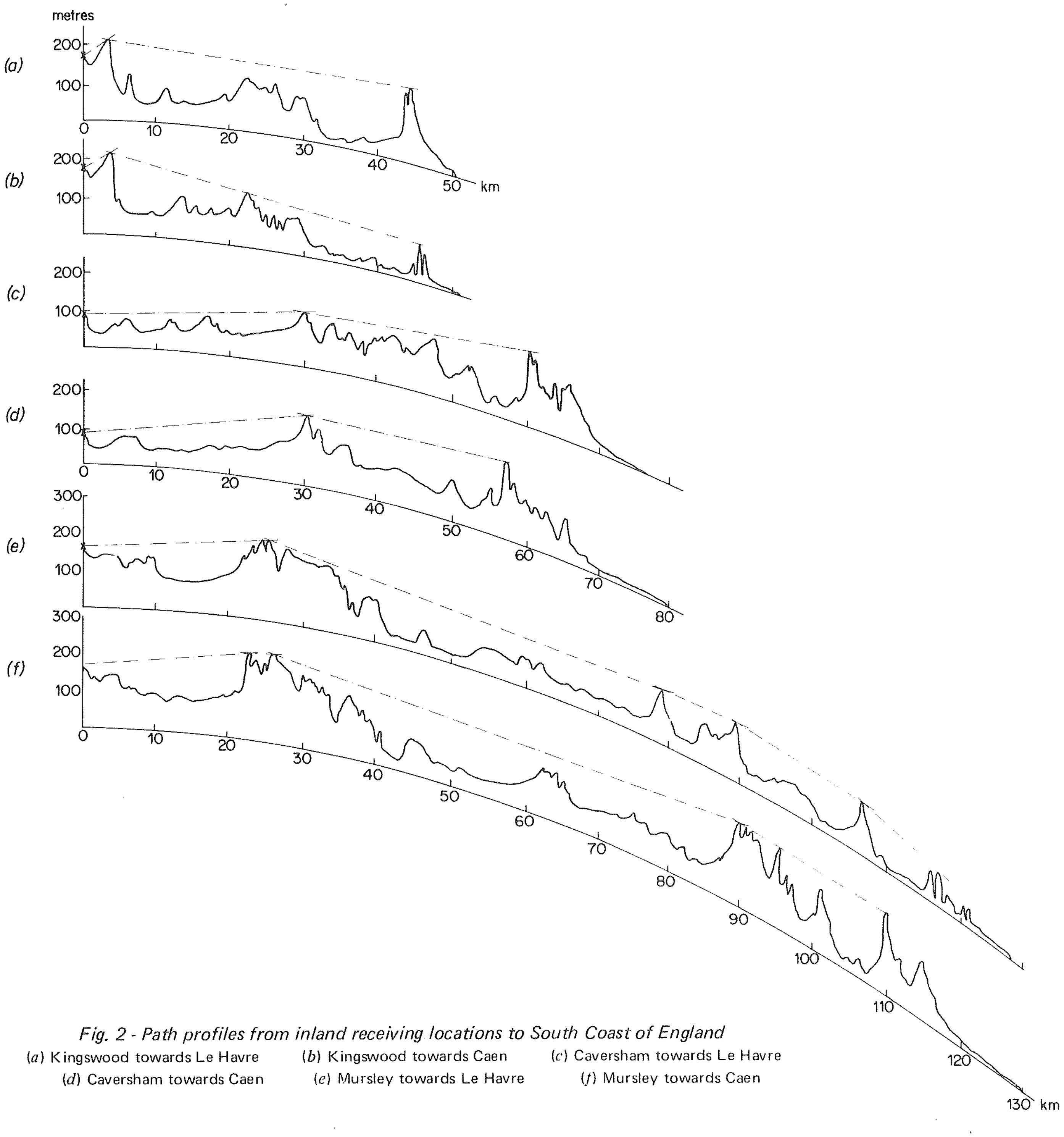

Fig. 2 - Path profiles from inland receiving locations to South Coast of England
(*a*) Kingswood towards Le Havre (*b*) Kingswood towards Caen (*c*) Caversham towards Le Havre
(*d*) Caversham towards Caen (*e*) Mursley towards Le Havre (*f*) Mursley towards Caen

TABLE 2

Receiving site details

Site	Site Height a.m.s.l. (m)	Receiving Ae. Ht. a.g.l. (m)	Latitude	Longitude	Path lengths						
					Tx. Caen			Tx. Le Havre			N.G.R.
					Land (km)	Sea (km)	% sea	Land (km)	Sea (km)	% sea	
Christchurch	18	4	50°44'06"N	01°43'04"W	45	165	78	8	187	96	SZ199929
Kingswood	167	9*	51°17'17"N	00°12'36"W	93	166	64				TQ248559
		14**	51°17'14"N	00°12'47"W				69	133	66	TQ246558
Caversham	82	12	51°28'50"N	00°57'21"W	121	158	56	92	142	61	SU725763
Mursley	158	9	51°57'14"N	00°48'03"W	171	158	48	141	137	49	SP 824291

* Aerial receiving Caen transmission

** Aerial receiving Le Havre transmission (mounted at this height to be clear of trees in the proximity of the receiving site)

TABLE 3

Results of measurements

Transmitter	Receiving Site	Measured field strength exceeded for specified time% [dB(μV/m) for 1kW e.r.p.)					Free Space Field Strength [dB(μV/m) for 1 kW e.r.p.]
		0·1%	1%	5%	10%	50%	
Caen	Christchurch	59·5(59·0)	50·5(50·0)	41·0(39·5)	32·5(31·0)	6·5(7·0)	60
	Caversham	33·0(34·5)	22·5(21·5)	13·0(13·5)	9·5(9·5)	–	58
	Kingswood	28·5(29·5)	19·0(18·5)	8·5(7·5)	3·0(1·5)	–	59
	Mursley	29·0(30·5)	15·0(18·0)	6·0(6·0)	3·0(2·5)	–	57
Le Havre	Christchurch	67·0(66·5)	58·0(57·5)	45·0(43·0)	34·0(31·5)	13·0*(15·0*)	61
	Caversham	35·0(35·0)	19·5(20·0)	13·0*(10·0*)	–	–	59
	Kingswood	32·0(35·0)	17·0(20·0)	8·0(10·5)	4·0*(6·0*)	–	60
	Mursley	33·0(37·0)	18·0(18·0)	13·5*(13·0*)	–	–	58

*Extrapolated values

N.B. Figures in parenthesis refer to first year of recording period

In the latter case a greater height (14 m a.g.l.) was used to be clear of trees in the immediate proximity. The aerials at Christchurch were mounted at the edge of a small sea-cliff approximately 15 m in height and therefore a receiving aerial height less than 10 m a.g.l. seemed appropriate. Details of receiving stations and transmission path lengths are given in Table 2.

3. Results

3.1 Analysis

The type of receiver used for the measurements has been described elsewhere.[6] These fixed frequency receivers were tuned to the sound channel* of the television transmission. Recording was by means of digital coding equipment[7] and recording milliammeter charts. The analysis was derived primarily from the punched tape output of the coding equipment, the chart recorders being used to provide a visual display of the fading characteristics. Recording times were arranged to cover the full daily transmission schedules of both transmitters. These records covered a period of almost exactly two years from 27th June, 1968 to 30th June, 1970 and were analysed to determine the length of time during which signal levels exceeded various values of field strength. These time durations, expressed as percentages of the overall valid recording time were then plotted against field strength in decibels relative to 1μV/m [dB(μV/m)] for an effective radiated power of 1kW.

3.2 Variation of field strength with time

The results of the measurements of the Caen (Channel 25) transmission are shown in Fig. 3*(a)* and of the Le Havre (Channel 43) transmission in Fig. 3*(b)*. Tabulated results of field strengths exceeded for specified time percentages are given in Table 3. In this table the corresponding results for the first half of the total period (i.e. July 1968–June 1969) are given in parenthesis. It will be seen that the results obtained over the first year correspond very closely with those for the full two year period of the experiment.

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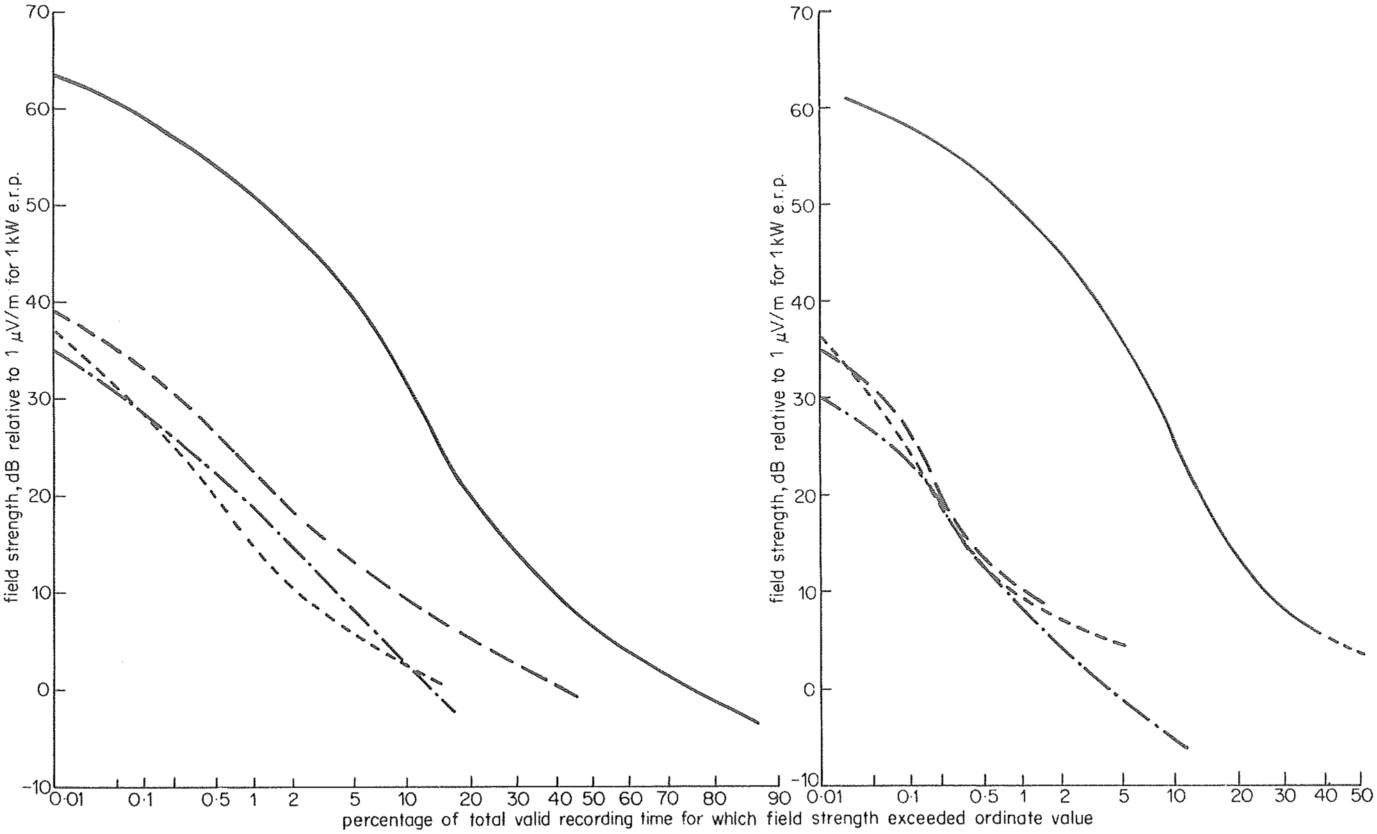
*At Kingswood it was necessary to transfer to reception of the Caen vision carrier for the latter part of the measurement programme due to adjacent-channel interference from the Crystal Palace transmission on Channel 26.



(a) *(b)*

Fig. 3 — Field strength distributions at the various receiving sites

(*a*) Transmitter — Caen (*b*) Transmitter — Le Havre

——— Christchurch — — — Caversham —·—·— Kingswood - - - - - - Mursley

3.3 Seasonal variations

Figures 4 and 5 show the variations in received field strength exceeded for specified time percentages in each month at the coastal receiving site at Christchurch. The following features may be noted:

(i) Although there are some minor anomalies (i.e. the high values in March and October 1969) there is a clearly defined seasonal trend with the greatest probability of abnormal propagation in the summer months. This seasonal pattern for propagation over sea paths around the United Kingdom was previously established on the basis of propagation experiments extending over a period of more than 10 years,[3,5,8,9] and is confirmed by measurements in the Baltic Sea area[10,11] at v.h.f., u.h.f. and s.h.f. Exceptions to the general pattern do, however, occur; for example one of the most prolonged periods of intense abnormal propagation observed in the earlier series of measurements made by the BBC occurred in December 1962.[5]

(ii) From Figures 4 and 5 it may be seen that the overall monthly variation in the field strength may exceed 35 dB at 10% time levels and may approach 50 dB for smaller time percentages. Even the monthly median value may vary by more than 20 dB between summer and winter.

(iii) The signal received from Le Havre exceeds the free space level for a greater percentage of time than does that from Caen. Although this difference is probably significant, it is not possible to determine whether it is a function of frequency or of the differing nature of the transmission paths.

Figures 6 and 7 show, for the Caen transmission, corresponding monthly variations in received signal levels at the inland receiving sites of Caversham and Mursley respectively. These variations might reasonably be expected to be similar to those at the coastal site (Fig. 4) in that conditions supporting abnormal propagation over the total land/sea path cannot exist unless they are at least present over the sea portion of the path. It is therefore of interest to note the points of difference between the seasonal trends shown in Fig. 4 and in Figs. 6 and 7. In particular:—

(i) The monthly variations over the mixed land/sea paths of 6 and 7 are far smaller than for the predominantly sea path (of Fig. 4), being no more than about 20 dB at the 10% time level and 25 dB for smaller percentages of time.

(ii) The seasonal trend towards high field strengths in the summer months is less pronounced over the mixed paths. In particular, at Mursley, the only occasions during

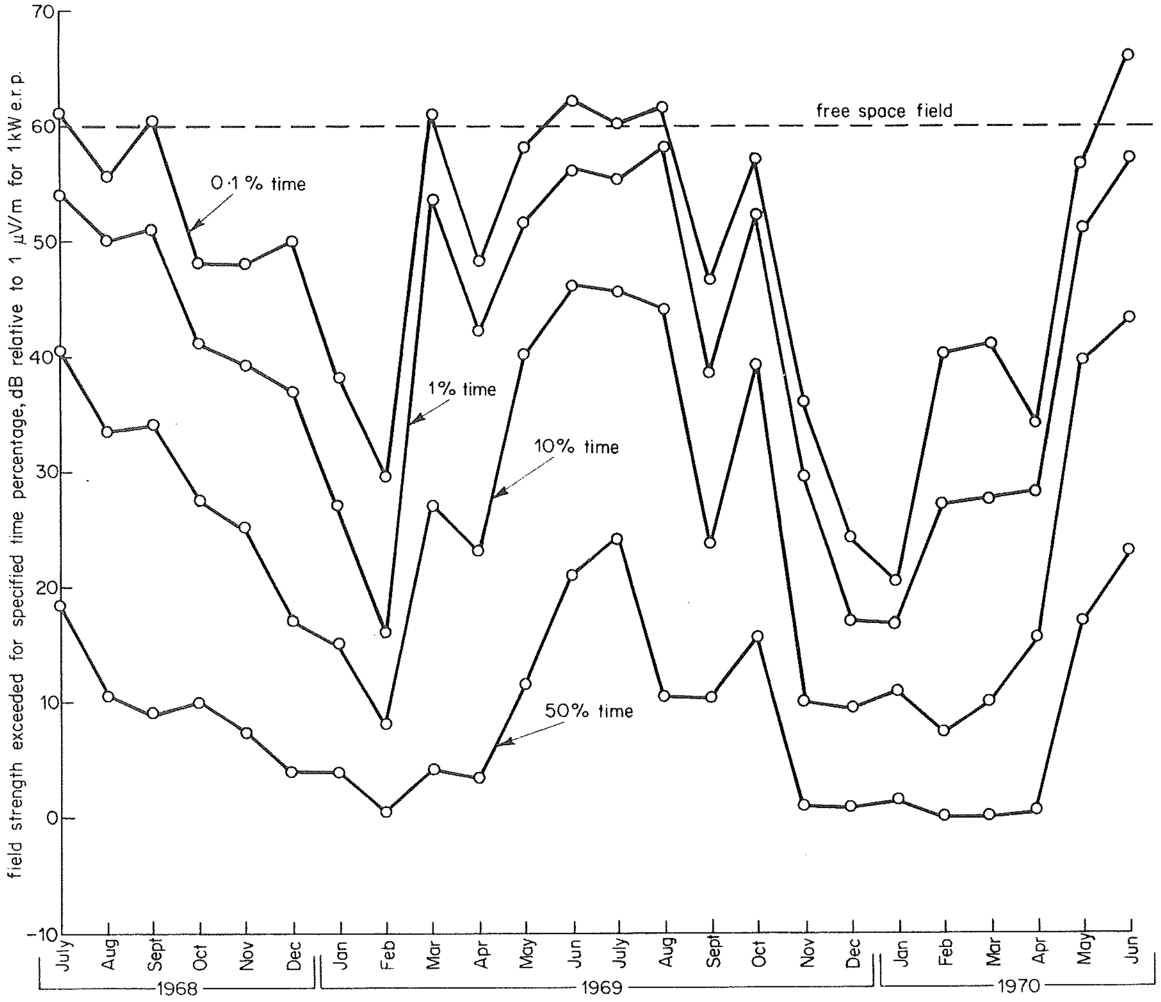


Fig. 4 - Monthly variations in received field strength: Caen transmission received at Christchurch

the measurement programme for which the received field strength approached within 20 dB of the "free space" value were during November/December 1968 and October/ November 1969.

Previous work[12,13] supports these conclusions concerning the differing times of occurrence of abnormal propagation over land and sea paths. In this context it is of interest to note the results of u.h.f. propagation measurements in the Baltic Sea area.[11] In this instance a comparison was made of simultaneous hourly median field strengths received over a sea path and mixed land/sea path of comparable length and using the same transmitting site. The results showed a low correlation between the times of occurrence of high field strengths, high fields over the sea path being associated with either high or low fields over the mixed path, whereas low fields over the sea path almost invariably coincided with low fields over the mixed path. Results of previous measurements[12,13] also indicate differing diurnal trends for abnormal propagation over land and sea paths. The form of analysis used in these latest measurements did not, however, permit an examination of such diurnal characteristics.

4. Comparison of measured results and predictions

4.1 Corrections for site variation factor

The receiving sites chosen for this experiment were not necessarily representative of the areas in which they were situated, whereas the CCIR field strength/distance curves of Recommendation 370-1[1] "apply to 50% of receiving locations in the rolling irregular terrain found in many parts of Europe and North America". Consequently if the measured results are to be compared with estimated values obtained from the CCIR curves it is necessary to apply an appropriate site variation factor (s.v.f.) correction to refer the results at individual sites to those representative of 50% locations.

In previous propagation experiments carried out by the BBC Research Department the practice has been, where possible, to determine the s.v.f. corrections by making field-strength measurements at a number of locations within some 10 km of the fixed site and comparing the results to the corresponding field strength at the fixed site for the period of time. In this instance it was not found practicable to carry out such measurements in view of the small proportion of the total time for which signal was received at the inland sites. Furthermore, as discussed elsewhere,[2,14] previous measurements have appeared to indicate that any measured s.v.f. correction may only be applicable to the particular propagation conditions occurring at the time of the measurements.

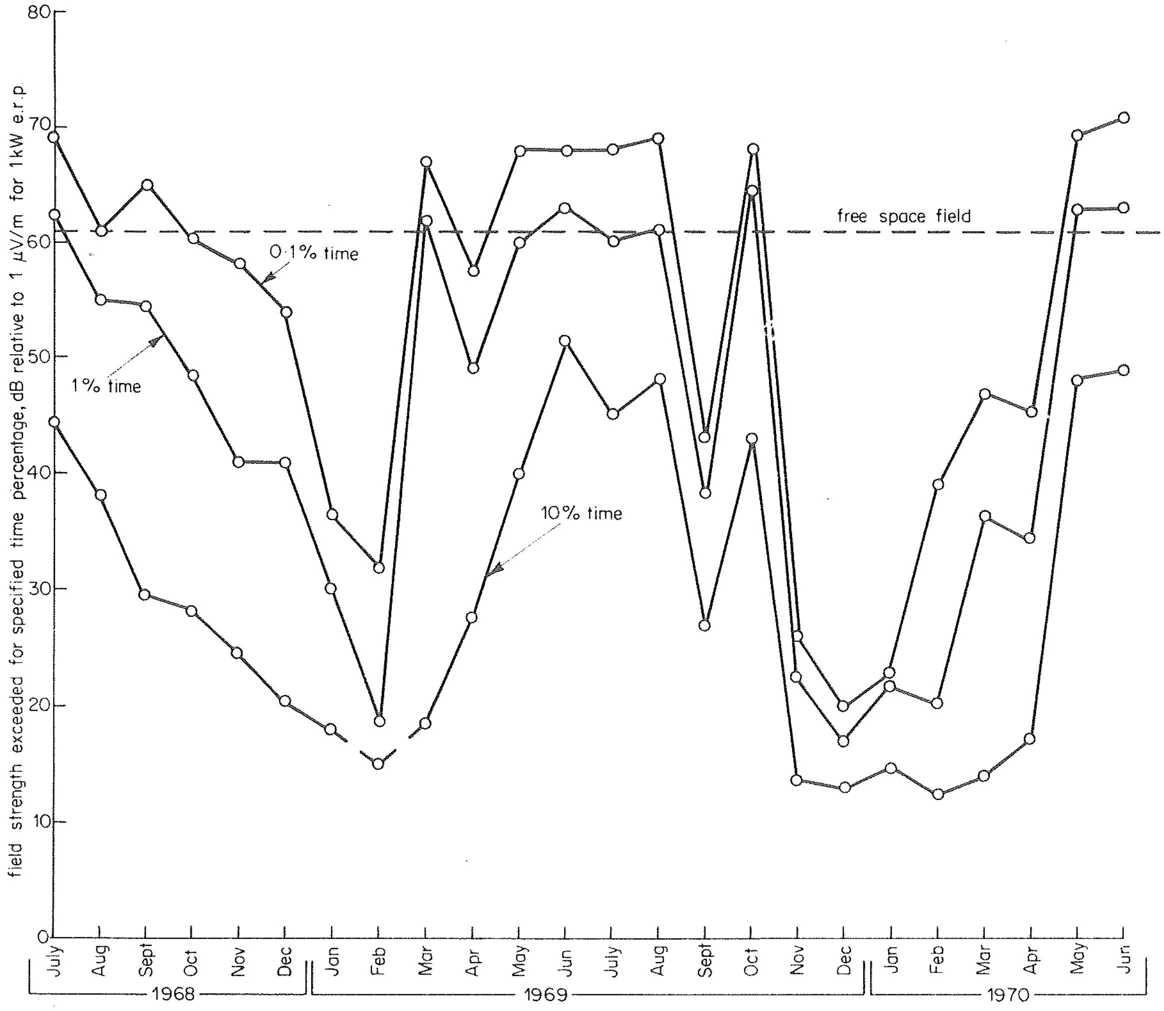


Fig. 5 - Monthly variations in received field strength: Le Havre transmission received at Christchurch

In view of these difficulties s.v.f. corrections for all sites except Christchurch are estimated on the basis of an empirical curve shown in Fig. 8 relating the correction (in decibels) to the elevation of the horizon (up to a maximum distance of 15 km) measured from the receiving aerial in the direction of the transmitter. This curve which was derived from an analysis of measurements at a great number of receiving locations within the service area of u.h.f. transmitters is the terrain correction curve used in the computer prediction Method A of CCIR Report 425.[15] Analysis of the data from which this curve was derived indicated that the horizon angle corresponding to an average (50%) location was 0·35°. The s.v.f. correction is thus referred to this datum rather than to the arbitrary datum of 0·221° of the curve represented in Report 425.

In addition to this s.v.f. correction (which takes account of the effect of terrain) it was considered appropriate to apply a further correction of +5 dB to the results at Kingswood to take account of clutter losses resulting from the wooded nature of the area in which the receiver was sited. This correction was applied only for reception of Caen since it was possible to mount the Le Havre receiving aerial to be rather more clear of local obstructions.

For the s.v.f. correction to be applied at the coastal receiving site of Christchurch reference should be made to Section 2 of CCIR Report 239-2[4] in which it is explained that u.h.f. oversea curves of Recommendation 370-1 were based upon measurements at open coastal sites directly overlooking the sea. In order to make these applicable to the calculation of co-channel interference in coastal areas, the curves incorporate a correction of approximately −7 dB. Since the site at Christchurch was also an open coastal site it was considered appropriate to apply this correction of −7 dB in this instance.

4.2. Comparison between measurements and predictions using CCIR Report 239-2 and curves of Recommendation 370-1

Table 4 gives a comparison between the measured results as corrected to be representative of 50% locations and the predicted values based on the curves of CCIR Recommendation 370-1[1] using the mixed-path interpolation method described in CCIR Report 239-2.[4] These

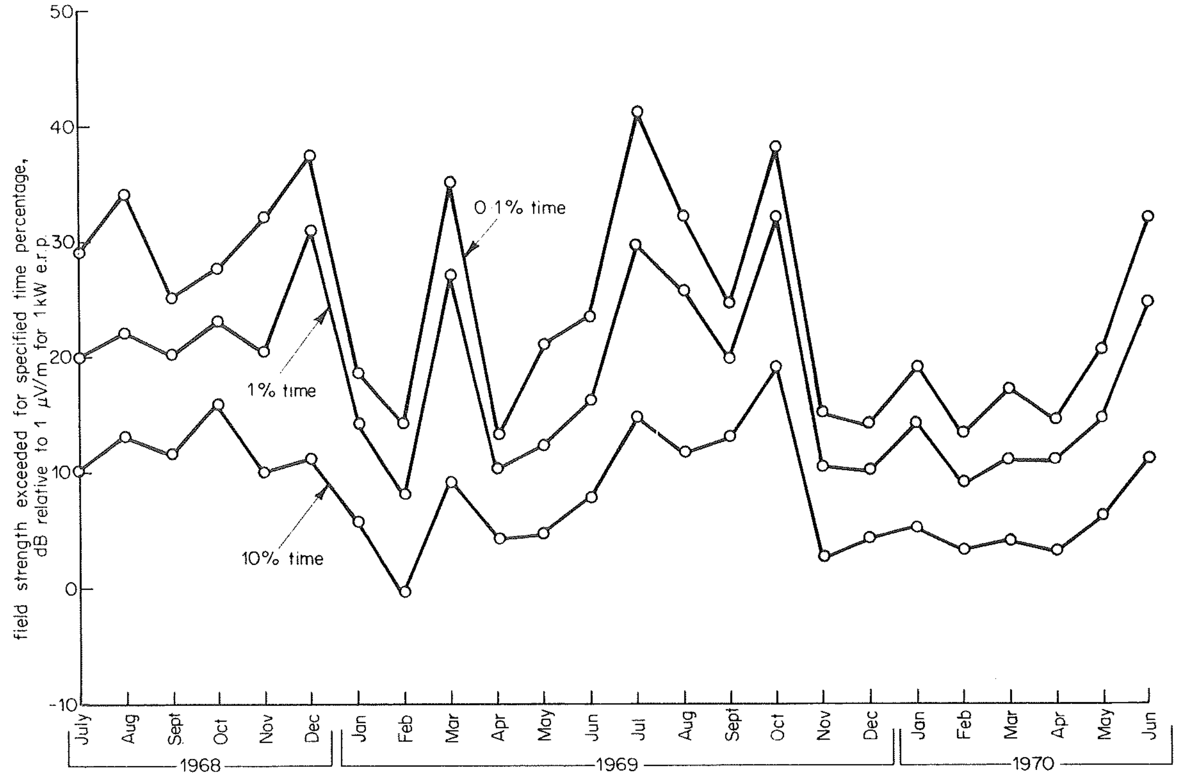


Fig. 6 - Monthly variations in received field strength: Caen transmission received at Caversham

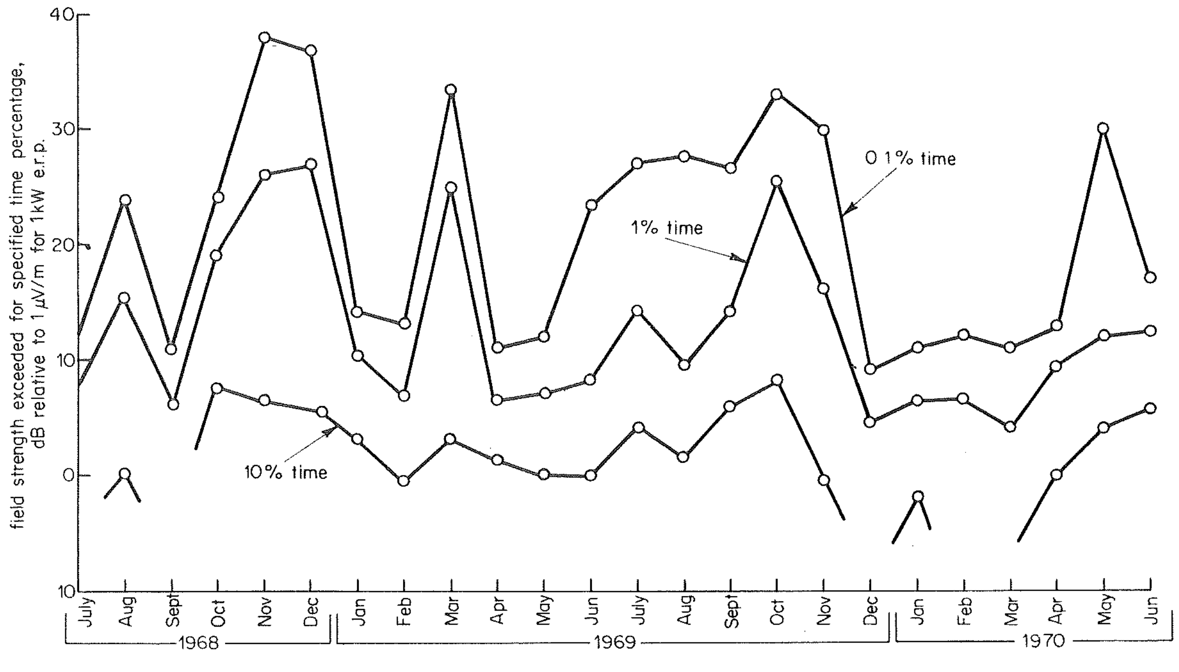


Fig. 7 - Monthly variations in received field strength: Caen transmission received at Mursley

predictions incorporate a correction (Δh)*, where appropriate, for the influence of ground irregularity.

This Table indicates that the prediction method gives reasonable agreement with the measured values at the coastal site (Christchurch) and for reception of Caen at Kingswood. For the remainder of the transmission paths the predicted field strength is invariably higher than the measured value. This is particularly noticeable for the results relating to reception of Le Havre.

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* Report 239-2 is not explicit as to the means of applying this Δh correction to mixed-path calculations. The method of Report 239-2 requires an average value to be taken from predictions made for both directions along the mixed land/sea path. It is not clear whether individual Δh corrections should be applied to both calculations or a single correction relating only to the actual transmission terminal applied to the averaged result. In Table 4 individual corrections have been applied. This seems the more appropriate method since it permits the introduction into the calculation of information regarding the nature of terrain at the receiving end of the path.

TABLE 4

Comparison between measurements and predictions obtained by method of CCIR Report 239-2

Path	Site Variation Factor (dB)	Measured Field Strength Exceeded for Specified Time Percentage Corrected to 50% Locations [dB(μV/m) for 1 kW e.r.p.]			$\Delta h_t^{\dagger}$	$\Delta h_r^{\dagger}$	Predicted Field Strength Exceeded for Specified Time % [dB(μV/m) for 1 kW e.r.p.]			Ratio of Measured to Predicted Field Strengths (dB)		
		1%	10%	50%			1%	10%	50%	1%	10%	50%
Caen – Christchurch	−7	43·5	25·5	−0·5	100	–	38·5	20·0	−0·5	+5·0	+5·5	0*
Caen – Caversham	−10	12·5	−0·5		100	20	21·5	6·0		−9·0	−6·5	
Caen – Kingswood	+4	23·0	7·0		120	25	26·5	9·5		−3·5	−2·5	
Caen – Mursley	−13	2·0	−10·0		100	50	12·0	−3·5		−10·0	−6·5	
Le Havre – Christchurch	−7	51·0	27·0	6·0*	–	–	56·5	22·0	0·5	−5·5	+5·0	+5·5*
Le Havre – Caversham	−10	12·5	–		–	20	27·0	–		−14·5		
Le Havre Kingswood	−1	16·0	3·0*		–	30	31·0	15·5		−15·0	−12·5*	
Le Havre – Mursley	−13	5·0			–	50	16·0			−11·0		

*Extrapolated values

†Δh_t and Δh_r refer to ground irregularities between 10 km and 50 km from transmitting and receiving locations respectively

TABLE 5

Results of previous measurements over mixed land/sea paths at U.H.F.

Path		Path Length (km)	% Sea	Effective Tx. Ae. Ht. (m)	Δh_t (m)	Δh_r (m)	Measured Field Strength Exceeded for Specified Time %[dB(μV/m) for 1 kW e.r.p.] Corrected to 50% locations			Predicted Field Strength Exceeded for Specified Time %[dB(μV/m) for 1 kW e.r.p.]			Ratio Measured to Predicted Field Strengths (dB)		
Transmitter	Receiver						1%	10%	50%	1%	10%	50%	1%	10%	50%
Crystal Pal.	Castleton	208	5	250	10	75	8·0	0	−9·5	15	5	–	−7·0	−5·0	–
Scheveningen	Tacolneston	217	81	60	–	8	44·5	20·0	–	31·0	14·5	–	+13·5	+5·5	–
Scheveningen	Manningtree	218	94	60	–	–	45·5	18·0	−2·0*	46·0	15·0	−7·0	−0·5	+3·0	+5·0
Lopik	Aldeburgh	232	77	150	0	–	37·0	8·0	−7·0	34·5	15·0	−2·5	+2·5	−7·0	−4·5
Scheveningen	Feltwell	258	67	60	–	7	22·0	5·5	–	20·5	3·5	–	+1·5	+2·0	–
Scheveningen	Gt. Baddow	262	90	60	–	–	33·0	9·0	–	33·5	7·0	–	−0·5	+2·0	–
Crystal Pal.	Stoke Fleming	275	30	250	10	–	−3·0	−12·0	–	15·5	3·0	–	−18·5	−15·0	–
Crystal Pal.	Halwell	283	25	250	10	–	18·0	0	−11	13	3	−13	+5·0	−3·0	+2·0
Lopik	Wickhambrook	305	59	150	0	30	15·0	−3·0	–	18·0	−4·0	–	−3·0	+1·0	–
Scheveningen	Brookmans Park	307	67	60	–	10	6·5	–	–	18·5	–	–	−12·0	–	–
Scheveningen	Morborne Hill	316	55	60	–	15	13·0	−6·5	–	11·5	−1·5	–	+1·5	−5·0	–
Scheveningen	Kingswood	321	79	250	–	70	13·0*	–	–	21·5	–	–	−8·5	–	–
Scheveningen	Skeffington	357	49	60	–	35	5·5	−22·0	–	8·0	−7·0	–	−2·5	−15·0	–
Dusseldorf	Aldeburgh	395	43	360	2·5	–	10·5	−16·0	−29·0	11·5	−16·5	−23·0	−1·0	+0·5	−6·0
Dortmund	Aldeburgh†	406	39	210	75	–	3·0	−15·5	−29·0	10·5	−11	−23·0	−7·5	−4·5	−6·0
Dusseldorf	Wickhambrook	466	33	360	2·5	30	2·5	−21·0	–	1·0	−15·0	–	+1·5	−6·0	–
Dortmund	Wickhambrook	479	33	210	75	30	14·0	−21·0	−32·0	−2·0	−21·0	−33·0	+16·0	0	+1·0
Scheveningen	Pontop Pike	511	74	60	–	150	6·0	−19	–	4·5	−22	–	+1·5	+3	–
Dusseldorf	Banbury	580	25	360	2·5	45	−26·0	–	–	−8·0	–	–	−18·0	–	–
Dortmund	Slough	588	39	210	75	10	−27·0	–	–	−9·0	–	–	−18·0	–	–
Coxhaven	Slough	685	72	150	–	75	−18·0	–	–	−15·5	–	–	−2·5	–	–

*Extrapolated values

†Measured values are mean of two successive sets of measurements

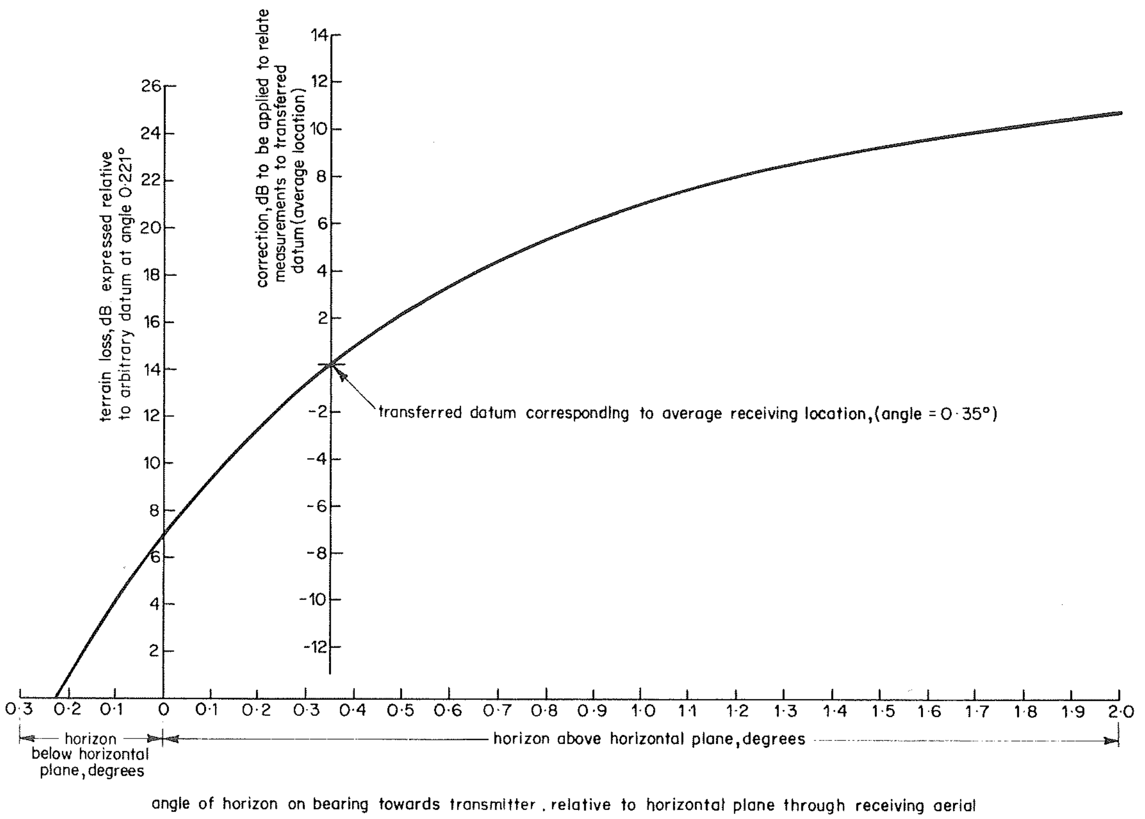

Fig. 8 - Receiving location correction curve
Original Fig. 5 of Report 1969/8

This series of measurements therefore confirms the conclusions from previous mixed path measurements carried out by the BBC,[5] namely that measured values were substantially lower than predicted values unless the percentage of land path was small.

Table 5 represents a comparison between measurements and predictions, similar to that of Table 4, for all other mixed land/sea paths traversing the North Sea or English Channel for which information is available. This Table includes the results of previous BBC measurements using Scheveningen as the transmitting source.

The comparisons between measurement and prediction for 1% and 10% times given in Tables 4 and 5 are shown graphically in Fig. 9 using an abscissa indicating the percentage of path over sea. This figure confirms the tendency for the prediction method to overestimate the field strength particularly at the 1% time level. The mean ratio of measurement to prediction is –4 dB for 1% time and –3 dB for 10% time, the r.m.s. errors of prediction being 9 dB and 6·6 dB respectively. The following features should be noted:

(i) For 1% time, measurements exceed predictions by more than 5 dB on only two paths. Of these, one set of results (Dortmund to Wickhambrook) related to measurements made over a period of only 5 months from June to October and is therefore probably not fully representative. The other set (for the path Scheveningen to Tacolneston) were obtained at one of the very few receiving sites having

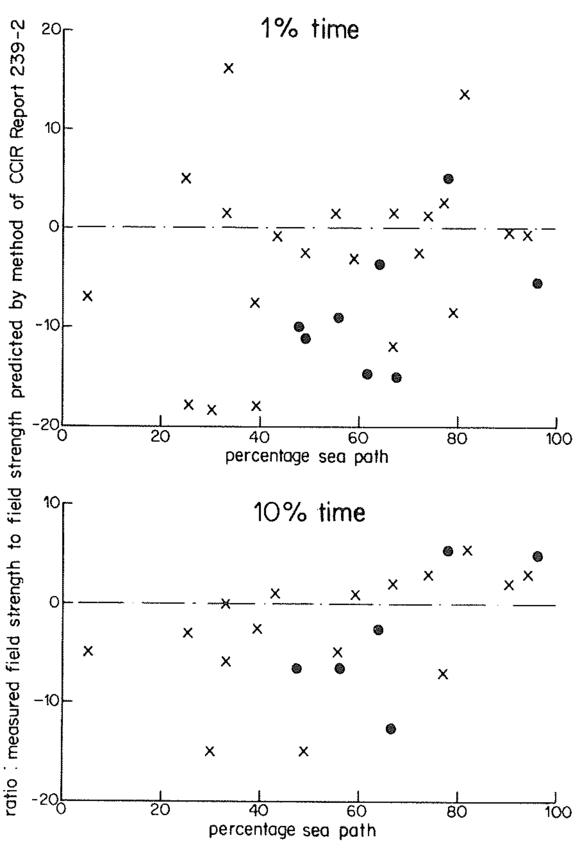

Fig. 9 - Comparison between measurement and predictions using method of CCIR Report 239-2
● Recent Results (Table 4) × Earlier Results (Table 5)

a large positive site variation factor, i.e. implying the receiving site to be a much poorer than average location.

(ii) Whilst the overall discrepancy between measurement and prediction is less for 10% time than for 1% time it must be appreciated that it was not possible to determine the "10%" field strength for almost a quarter of the total number of paths. In general these are the paths for which the measured 1% time field strength was substantially lower than predicted, and it therefore seems likely that there would have been a corresponding error for the 10% time prediction.

Several modifications to the prediction method were investigated with the aim of improving the correlation with measurements. Bearing in mind the desirability of retaining where possible the existing parameters used in Recommendation 370-1, the modification showing most promise is that of interpolating between curves for differing time-percentages. Thus to predict the field strength exceeded for 1% of the time over a predominantly* oversea mixed path the method described in Report 239-2 is followed but using the 1% time oversea curve and a nominal 5% time** overland curve. For a path which is predominantly overland the 1% time land curve is used in association with the 5% time oversea curve. Similarly to predict the field strengths exceeded for 10% of the time interpolation is between the appropriate 10% and 50% time curves.

Recalculation of the predictions in Tables 4 and 5 by this modified method gives mean measurement to prediction ratios of zero for both 1% and 10% times. The r.m.s. errors of prediction are also slightly reduced, these being 8·3 dB for 1% time and 4·4 dB for 10% time.

Although this modification to the mixed path prediction method of Report 239-2 is basically empirical it has some practical foundation in taking cognizance of the differing times of occurrence of abnormal tropospheric propagation over land and sea paths.

4.3 Comparison between measurements and predictions using Method A of CCIR Report 425

For reasons which are fully discussed elsewhere,[16] the BBC does not use the prediction method of CCIR Recommendation 370-1 and Report 239-2 for frequency planning in the u.h.f. broadcast band. In view of the very great amount of prediction work required to assess co-channel interference levels in this expanding network it was considered essential to produce a method suitable for computer use. Two such methods[16,17] have been developed, the more recent of which comprises Method A of CCIR Report 425.[15]

It is of interest therefore to assess the accuracy of this prediction method in a manner similar to that for the first prediction method (Fig. 9). This comparison is shown in Fig. 10. In this instance, however, the comparison is carried out at the 1% and 5% time levels, the 5% level being more relevant than the 10% level for planning purposes.

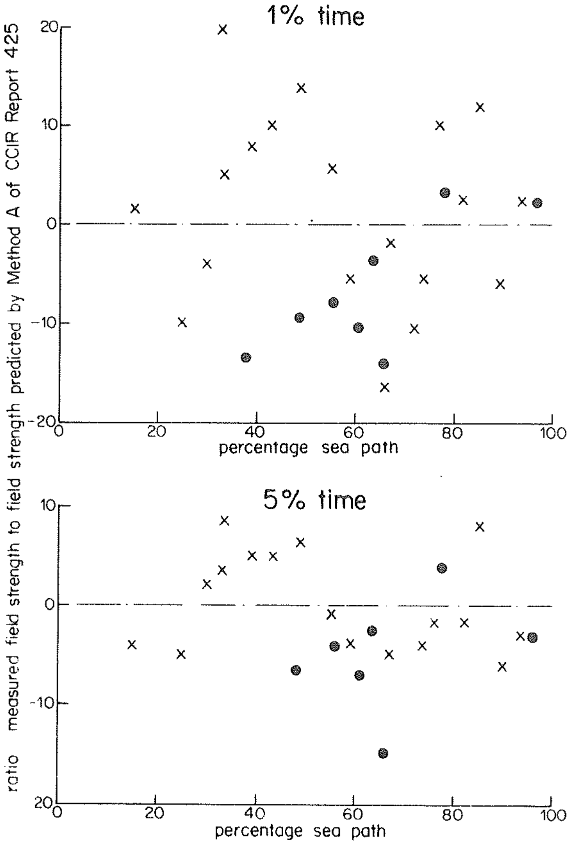

Fig. 10 - Comparison between measurements and predictions using method A of CCIR Report 425

● Recent Results (Table 4) × Earlier Results (Table 5)

The following features may be noted from Fig. 10.

(i) The tendency to overestimate the field strength is much less pronounced than in Fig. 9, the mean value of measurement to prediction ratio being about 1·5 dB for 5% time and less than 1 dB for 1% time. This reduction is however to be expected since all the measurements of Table 5 were used in the optimisation procedure for determining the parameters of the prediction method and in particular of the weighted interpolation curves comprising Fig. 7 of Report 425 (reproduced here as Fig. 11).

(ii) The r.m.s. error of prediction for 1% time is 9·2 dB, i.e. is slightly greater than for the method of Report 239-2. It should however be pointed out that, whereas a measured or estimated site variation factor is required to normalise the measurements to 50% locations in order to produce the comparison in Table 5 and Fig. 9, this location correction is inherent in the prediction method of Report 425. In fact the r.m.s. error for 5% time in Fig. 10 is 5·5 dB which compares favourably with the value of 6·6 dB at 10% time in Fig. 9.

(iii) Except for those paths containing only a small proportion of land the results of the latest series of measurements show this prediction method to consistently overestimate field strengths, as also does the previous method. Part of this error is almost certainly due to the fact that both prediction methods were based on data relating to propagation paths crossing the flat terrain of East Anglia and the Netherlands. As indicated by the path profiles of Fig. 2 the latest results relate to propagation over much more undulating terrain.

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* i.e. more than 50%.

** Assumed for the present purpose to be the mean (in dB) between 1% and 10% curves.

Some small improvement in the prediction accuracy of the existing BBC computer method might be possible, taking into account the additional mixed path measurement data now available, either by re-optimisation of the land/sea interpolation curves, or by interpolating between curves for different time percentages (as suggested in this report for predictions using the Report 239-2 method). No examination of the usefulness of such means of improvement has been attempted since it is considered that significant improvements can be achieved only by taking into consideration the full path profile between transmitting and receiving location. Computer data-storage techniques now make such detailed predictions feasible and prediction methods currently being developed within the BBC are based upon the availability and use of such terrain data banks.

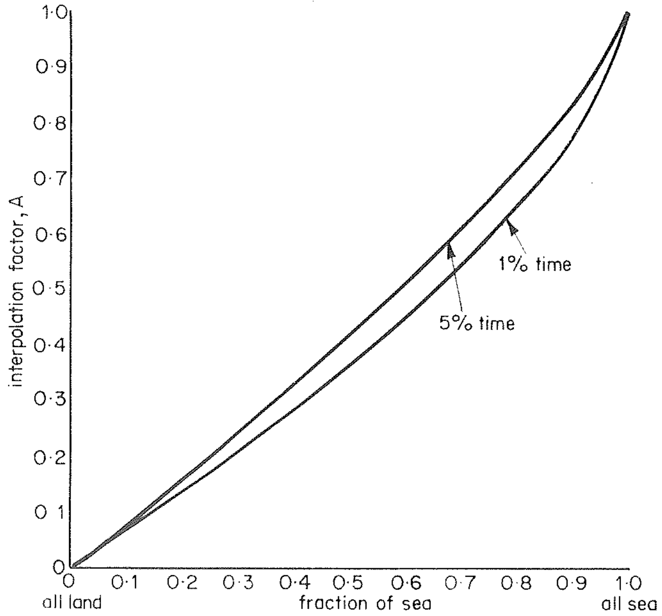

Fig. 11 - Land/sea interpolation factor
Original Fig. 5 of Report 1969/33

5. Conclusions

The results of the measurement programme described in this report provide a useful addition to the somewhat limited statistical data available regarding u.h.f. propagation over mixed land/sea paths, and required for frequency planning purposes. In particular, the paths investigated provide almost the only available information regarding propagation over paths traversing the English Channel and the undulating terrain of Southern England. The majority of previous measurements, upon which current prediction methods are based, related to propagation over the flatter terrain of East Anglia and the Netherlands. It is therefore not surprising that use of current prediction methods tend to overestimate the field strength received at the inland sites used in this latest measurement programme.

A modification to the CCIR prediction method of Recommendation 370-1 and Report 239-2 is suggested which would slightly improve prediction accuracy without requiring modification to the existing curves or the introduction of additional parameters. Such a modification is however of little practical importance to the BBC since this prediction method is no longer used for u.h.f. planning purposes.

Although some improvement to the existing BBC prediction methods might be obtained if this additional data is taken into consideration, it is felt that significant improvements will require radical changes in prediction technique. Such techniques currently under development entail calculations involving a knowledge of the full transmission path profile. In applying these methods to the problem of abnormal tropospheric propagation over mixed land/sea paths it will be necessary to take account of the reduction in expected field strength exceeded for specified time percentages resulting from the differing times of occurrence of abnormal propagation over the land and sea portion of the path.

6. Acknowledgments

We are indebted to the following for providing the facilities necessary for carrying out the measurements described in this report:

(i) The Director of the Signals Research and Development Establishment, Christchurch.

(ii) The Buckinghamshire County Constabulary.

Thanks are also due to members of staff at SRDE Christchurch and to the Engineer-in-Charge and staff at the BBC Monitoring Station Caversham for the routine checking of recording equipment carried out on our behalf; also to Mlle Huet of the ORTF for providing information concerning transmissions from the stations at Caen and Le Havre; and to Mr. P.J. Brice of the Ministry of Posts and Telecommunications who collated the information regarding earlier measurements quoted in this report.

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DC/EP

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey